

**IMPROVING COGNITIVE INDEPENDENCE OF  
DEMENTIA PATIENTS USING MACHINE  
LEARNING ENABLED MOBILE  
APPLICATION**

Project Id: 2023-081

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology

Department of Data Science

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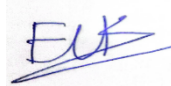
Sri Lanka Institute of Information Technology

Sri Lanka

March 2023

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## ABSTRACT

Dementia is the loss of cognitive functioning such as thinking, remembering, reasoning and decision-making that interrupts a person's daily day-to-day activities. This occurs because of the damage that happens to the brain cells which interferes with the communication of that person that affects thinking, behaviours and feelings. Most Dementia patients have got wandering as one of their major concerning habits, where they may leave their home or the place, they should be without informing or notifying others. Since Dementia patients are frequently suffering from short-term memory impairment, this can lead to a dangerous accident for the patient. Also, with the busy workloads that caregivers or family members have due to the current complex society, they might not be able to keep their focus on the Dementia patient all the time. By frequently using living activities, caregivers are encouraged to help the patients, but they need to promote their self-independence at the same time. Then most Dementia patients have a habit of notifying themselves about the current date, time, and weather conditions. Although there are tracking mechanisms around the world, there are few location tracking systems available which have been specified only for Dementia patients but most of them are not user-friendly and vulnerable in certain situations.

Therefore, an innovative, user-friendly, smart solution is needed. The IoT can provide a reliable, sustainable, and fully functional solution for these problems by using sensors to monitor the movement and track the location of patients [1]. By using interconnected sensing technology, the possibility is there to solve the above-mentioned two major problems that happen with their habits. This device provides benefits for both parties; patients and caregivers by serving as a smart wearable device to view dates, times, and weather from the patient's perspective while the caregiver can predefine the safe zones according to the whereabouts and track down the movement of the patient by using sensors and trackers. If the patient goes out of those defined safe zones, caregivers are notified in real-time and can call the patients via the device to prevent any dangers. As an additional feature, by using ML, this device keeps historic records about the places the patients have visited so it can analyze and understand to predict the patient's habits to help the caregiver to take necessary action for the care and safety of the patient.

Keywords - Dementia, wandering, memory impairment, Internet of Things, sensors.

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## LIST OF ABBREVIATIONS

Abbreviation	Description
IoT	Internet of Things
ML	Machine Learning
WSD	Wearable Sensing Devices
WHO	World Health Organization
RAM	Remote Activity Monitoring
WBS	Work Breakdown Structure
ANN	Artificial Neural Network

# 1. INTRODUCTION

## 1.1 Background and Literature Survey

Dementia affects cells in the brain that controls memory. People with dementia are often compelled to walk about. They don't have a place to go or go somewhere without knowing where they are heading. With memory impairment, they just feel the need to walk and move aimlessly and this can be defined as "wandering" [2]. Stress or fear, overstimulation and frustration cause wandering emotionally while poor dimension perception, visual-spatial problems, poor eyesight, and mobility can be physical causes. At night, boredom, perceived obligations, physical discomfort and being too hot or cold can cause the same behaviour [3]. In this study, we looked at the wandering problem and its effect on Dementia patients and their caregivers. Research that has been done previously indicates that Dementia wandering is more lethal than people think in general. According to Alzheimer's Association 60% of people with dementia are wandering during the cause of the disease [4]. There is no clear reason for this behaviour and it is quite interesting. Thus, wandering is unpredictable [5].

As the caregiver, are you experiencing wandering as a habit of the diseased person ?  
102 responses

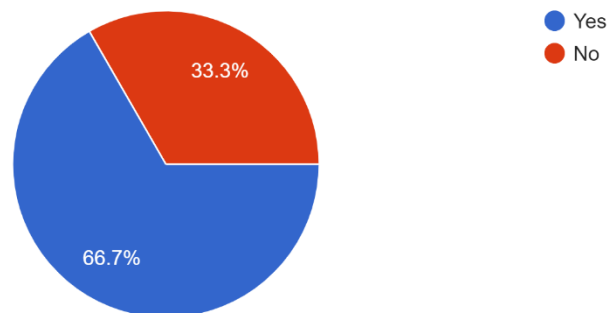


Figure 1.1. 1: Survey results on the frequency of wandering as a habit of dementia patients

The number of people that are diseased with dementia is rising today at a larger scale. Since the beginning of 2020 due to Covid-19, people were forced to stay at their homes and elder

people who are living lonely have been affected by this to be victims of mental illnesses. Dementia has become the most common illness among them [6]. At the same time, studies show that people who were dealing with dementia morbidity and mortality from Covid-19 [7]. Although currently, people are living in post-pandemic, for elderly people it has become hard to adapt to the era of new normalization. So, in the post-pandemic, they tend to travel a lot but with short-term memory impairment, the risk of wandering is high, and this can be highly hazardous. Then caregivers need to pay more attention and put more focus towards the patients than ever before.

WSD and IoT have been identified as two of the most evolving and emerging technologies, they can be used to revolutionize the existing solutions for the wandering problem of dementia patients. Since the beginning of Covid – 19 pandemic, monitoring patients remotely has evolved significantly and it has become synonymous with the health industry with the introduction of Mobile Health [8]. With the growth of user acceptance of smartwatches for medical purposes, the general public’s motive towards using technology is to reduce the complexity of their lives [9]. With the implementation of the sensors, identification of the patterns of movements of a patient can be done up to a certain extent so a behaviour out of the ordinary could be detected, identified, and reported on. It is also important to maintain bidirectional communication between the patient and the caregiver since it helps to keep the mental stability of the patients, but it is an extra burden for caregivers [10].

As the caregiver, you find it hard and stressful to keep up your focus with diseased person all the time ?

100 responses

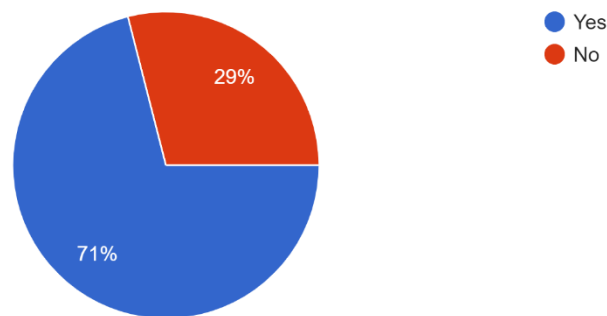


Figure 1.1. 2: Survey results on the stressful nature and the burden on caregivers of dementia patients

## 1.2 Research Gap

When considering the whole system, there is a very limited number of devices and tools which have been implemented to assist Dementia patients, but the wandering problem has not been addressed by most of them. Also, they lack certain key functionalities and some of them are highly outdated. Because of this, caregivers search for new technical solutions which are current and futuristic. Most existing options have not been built to establish safe zones facility for caregivers which can massively impact the well-being of the patient and minimize the burden on caregivers' shoulders.

What do you think about the accuracy of those existing applications and tools that have been build to aid the people with dementia ?

104 responses

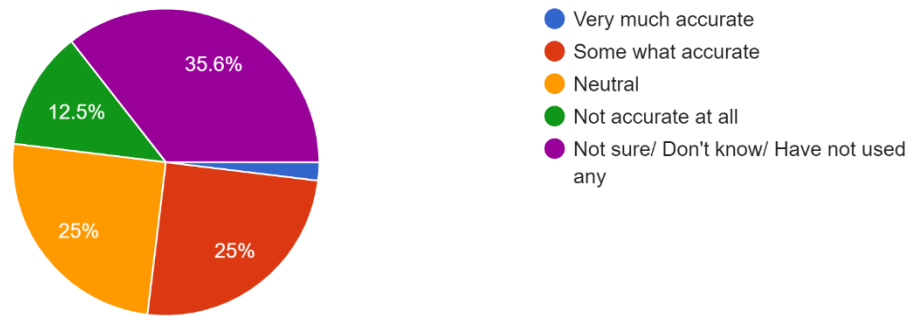


Figure 1.2. 1: Survey results on user experience and satisfaction with existing applications and tools

What are the flows you see on those applications/ tools ?

104 responses

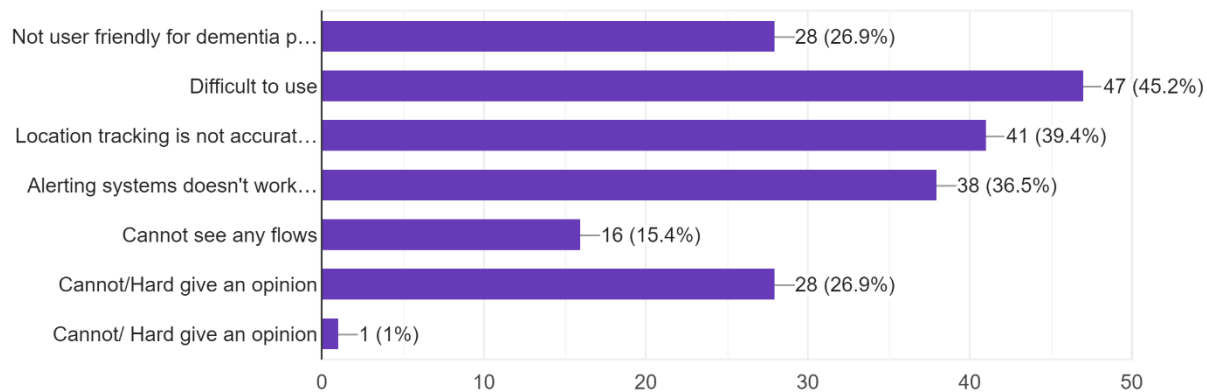


Figure 1.2. 2: Users' ideology about existing tools and their flows/ what areas mainly need to address

Providing the capability for the patient to know the date, time, and weather, whenever he or she needed is something that helps to maintain the mental stability of the patient and that feature cannot be found which has been made for the targeted audience. This is something that experts have found recently since this has become one major habit among people with this particular disease. Generally, there are smart watches that provided more facilities than this but when it comes to people with dementia, it is important to keep details short, simple, and interactive so they do not have to stress and panic which may result in a worse manner.

Although there are some research has been done regarding the wandering problem of dementia patients, certain implementations cannot be found in the real world [11]. Research A [12] paper explains assistive mobile health applications and wearable IoT devices have been developed for patients who are in the early stages of Alzheimer's disease (which is a diagnosis of dementia) to maintain their mental activeness. Research B [11] paper explores the movement and location tracking mechanism that has been built for dementia patients. Research C [13] (Real-time Location Tracker for Critical Health Patient using Arduino, GPS Neo6m and GSM Sim800L in Health Care) paper describes the real-time location tracking system which has been built using sensors, google maps and tools such as Arduino boards.

Table 1.2. 1: Research gap by comparing the proposed system with existing systems

	Research A	Research B	Research C	Proposed system
Track the current location of the patient and monitor movement and speed constantly	✗	✓	✓	✓
Establish safe zones and change them according to the whereabouts at the time by caregivers	✗	✗	✗	✓
Analyze patient's historical records and predict future movements	✗	✗	✗	✓
Bidirectional communication	✗	✓	✗	✓
Alarming & alerting system for emergencies	✗	✓	✗	✓
Show the current date, time, and weather whenever the patient needs	✗	✗	✗	✓

Since there is no research or an existing application that utilizes the patient's history records about the places he or she has visited more frequently in order to analyze and predict patient's movement, in order to minimize/prevent future disasters from happening and also that satisfies one of the most common habits of the patient's to know date, time and weather conditions, we propose to develop an IoT device to fulfil the above-mentioned features to bridge the research gap.

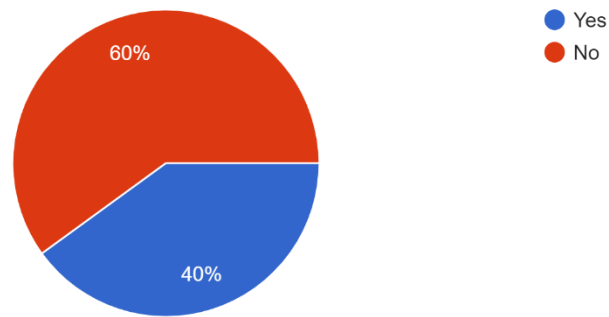
### 1.3 Research Problem

The public does not consider wandering as a major concern but when it comes to Dementia, it can be considered one of the most complex, dangerous, and challenging behaviours that can cause elopement, being lost, fatal injuries or even death at certain times. Inability to

memorize all the activities and places that patients visit due to partial memory impairment highly impacts this. As shown in figure 1.5.1, the fatality rate among dementia patients is high. In figure 1.5.2, some users have shared their experiences and clearly, it shows that the patients were so close to their death. Certain studies and estimations suggest about 50% of dementia patients who wander either suffer from serious injuries or die unless they were not found within the next 24 hours.

Has the patient under your supervision experienced any fatal injuries/ accidents because of wandering ?

100 responses



*Figure 1.3. 1: Survey results on fatal injuries/ accidents that have happened because of wandering*

If the answer is "Yes", please explain that experience.

18 responses

Wounded by a street dog while wandering
Once the patient was at a car crash site and he has been at the middle of the road.
Once when we went to a forest my grand mother lost and we found her while she was sinking in a river.
About 6 months ago my grand father was lost for 12 hours and a neighbour found him wounded after falling down.
My mother bumped into a car while wandering
My mom was drawing on a pool.
My father nearly died when he was wandering at night. We could not find him for 24 hours.
My aunt was wandering at once she was attacked by a dog.
My mother was attacked by a street dog while wandering and wounded

Figure 1.3. 2: Some experiences shared on fatal injuries/accidents that have happened in detail

## When a person goes missing



Figure 1.3. 3: Previous research results on the impact of wandering



From caregivers' perspective, this is a more exhaustive habit that they need to be concerned about regarding dementia patients' safety. Patients need constant supervision to reduce and prevent harmful scenarios that they might have to face but caregivers cannot prioritize their supervision on a patient all the time due to their hectic and complex lifestyles. The obvious option for them to avoid those circumstances is to lock in the patients at a certain place to reduce mobility but it impacts other sides of those diseased people as well. For example, the main impact is its severe impact on their independence. Also, this can lead to them being immobilized as well.

The WHO encourages countries to work towards some goals by 2025 to increase the quality of life of dementia patients and increase awareness about the disease among the public. So, it is important to give technical solutions that can be effective for this good cause.

RAM systems have been proposed for the caregivers of patients since those systems can be valuable aids for them. There were certain limitations and faults in already existing tools alongside this feature such as false alarming. But features such as the importance of alert context, accuracy and type of altering have been highlighted in recent qualitative results gained research [14]. Establishing safe zones and notifying them when an emergency happens removes some heavy burden from the caregivers' shoulders regarding their responsibility towards dementia patients.

Then there are no methods to predict patients' future movements while analyzing their past records. This can be a major help for caregivers since some studies have found out that patients tend to follow certain patterns when they wander. If the caregivers have this option, it creates a less stressful environment. Also, the deceased person can live with society with some independence to a certain extent while under someone else's supervision. This minimizes fatal accidents and injuries and can even stop untimely deaths that could happen to the targeted audience and prevent critical disasters.

Out of the followings, what features do you think is most helpful in taking care of a dementia patient to ease our burden as the caregiver ?

105 responses

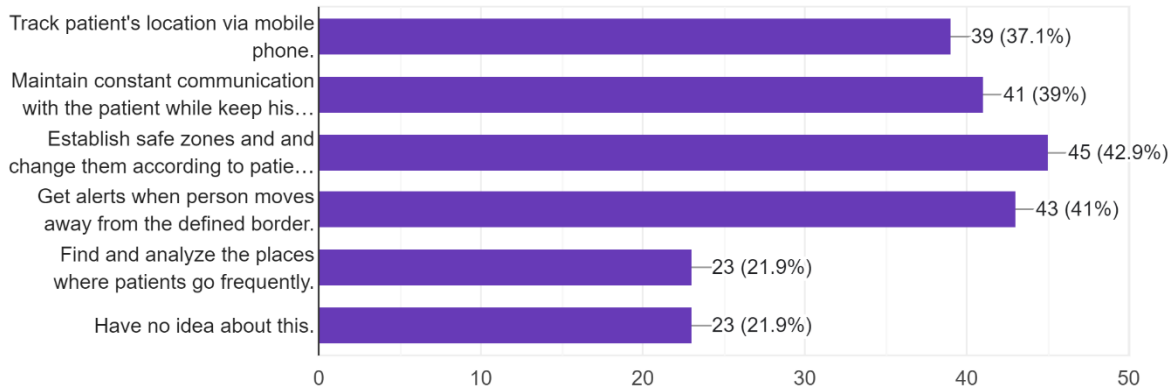


Figure 1.3. 4: Users' responses to the proposed features of the system via the survey

In this proposal is mainly addressing about the wandering behaviour of dementia patients with its impacts on both patients and caregivers, constant monitoring of the movement speed of patients, establishing safe zones and changing them according to the patient's current environment, bidirectional communication between the caregiver and the patient, analyze and predict patients future movements using historical records while fulfilling the wish of a dementia patient to know about current date, time, and the weather condition.

## **2. RESEARCH OBJECTIVES**

### **2.1 Main Objective**

The main objective of this research study is to provide a smart solution for the wandering behaviour of dementia patients by inventing an IoT device to track locations while establishing safe zones and analyzing their movement patterns for future predictions while maintaining the bidirectional communication between the patient and the caregiver by providing an interface for the patient to view real date, time and weather conditions at the time.

### **2.2 Specific Objective**

With the above-mentioned main objective, the following specific objectives are intended to be accomplished when it comes to the whole component and overall implementations.

#### **To track patients' locations in real-time and maintain bidirectional communication**

- When considering wandering, the main goal is to constantly be aware of the people who wander and the places they visit. For that, a real-time location tracker is required. Although similar implementations are already in the real world, their lack of accuracy has been highlighted by the caregivers. And caregivers are instructed to maintain communication with the diseased person. The IoT device will capture the real-time location of the patient using ANN and caregivers can view it using their mobile devices. Then there will be the option to call caregivers via their mobile devices and connect with the patients whenever they want.

#### **To identify the established safe zones with customizable options while giving alerts to caregivers in emergencies**

- Since ANN is used to convert identified locations in the real world virtually, we need a suitable and matching method to establish boundaries in the virtual map while analyzing the real geographical locations. For this geofencing will be used since it has the most efficiency and reliability. Alerts will be triggered when

patients cross those defined virtual boundaries. The option to customize those boundaries according to the place will be provided to the caregivers.

**To build a predictive model to analyze patients' historic records and predict future movements**

- After gathering location-related data via ANN, the same can be used to predict future movements using ML techniques. Classification and K-Nearest Neighbor algorithms will be used to generate predictions with high accuracy.

### 3. METHODOLOGY

The entire research focuses on implementing a system for improving the cognitive independence of dementia patients using an ML-enabled mobile application. The individual contribution towards the project is to research, study and analyze the wandering habit of dementia patients and provide a timely and efficient solution for that.

Building a wearable tracking device for people with dementia disease using IoT is one of the major solutions that can be presented for wandering problems. Real-time location monitoring via a mobile phone is releasing most of the stress from the caregivers of those patients since they must keep their focus on them all the time. Additionally, defining safe zones and changing them according to the patient's current surroundings is beneficial for both those parties. Sensors will be used for location and movement tracking functionalities while providing caregivers to define safe zones according to their will through the mobile applications.

For the device implementation, microcontrollers, sensors, actuators, enclosures, displays and batteries will be used in the proposed device. Microcontrollers help to make efficient, well-functioning and more realistic location monitoring devices [15]. Actual real-time data can be captured using sensors. In location tracking systems, it has been highly effective [16]. By using enclosures, we can improve the security of the IoT device while reducing the development cost as well. Displays and actuators are used for alerting and alarming functionality while batteries are used as the power source of the device since it is a smart wearable device.

ANN is used for patients' location tracking since it can provide real-time parameters and measurements with high accuracy [17]. Geofencing will use for defining safe zones. It artificially creates barriers to real geographical locations [18]. Caregivers can constantly monitor the patients' location as well as their movement whenever they want. When patients exit or enter the defined boundary, the system can trigger specific actions such as sending alerts to the caregivers. Although patients cross the safe zones, their location will be monitored every time and if they return to the safe zone before anything happens, it also will be notified to those who are supervising the patients.

All the historical data regarding the places that the patients mostly visited or frequently visit, how many times he or she has crossed the defined safe zones, and patterns of movement will be stored within the system and after 6 months period, a new feature will be available for caregivers where the system is predicting the movement of the patients by analyzing and training those gathered data. Since the use of ANN for the location tracking feature, the same ML method can be used for these predictions too because it provides predictions with high accuracies by using techniques and algorithms such as Classification and K-Nearest Neighbor algorithm which can satisfy caregivers' requirements [19].

To maintain bidirectional communication between patients and caregivers, Caregivers have the facility to call the patient via their mobile phones and the patient can reply to that. The patient does not need to do anything since, 3 seconds after receiving the call, the device will automatically answer the call for the patient without any physical interaction between it and the patient currently wearing it.

Patients can know the current weather condition, date, and time via the wearable device. So, the product will be beneficial for both parties. It addresses another habit dementia patients have, and this is done according to the recommendations made by experts in the relevant field. Displaying weather will be done by connecting to the database of the Weather department and the date time will be displayed by connecting to a date time application.

### 3.1 Software Solution

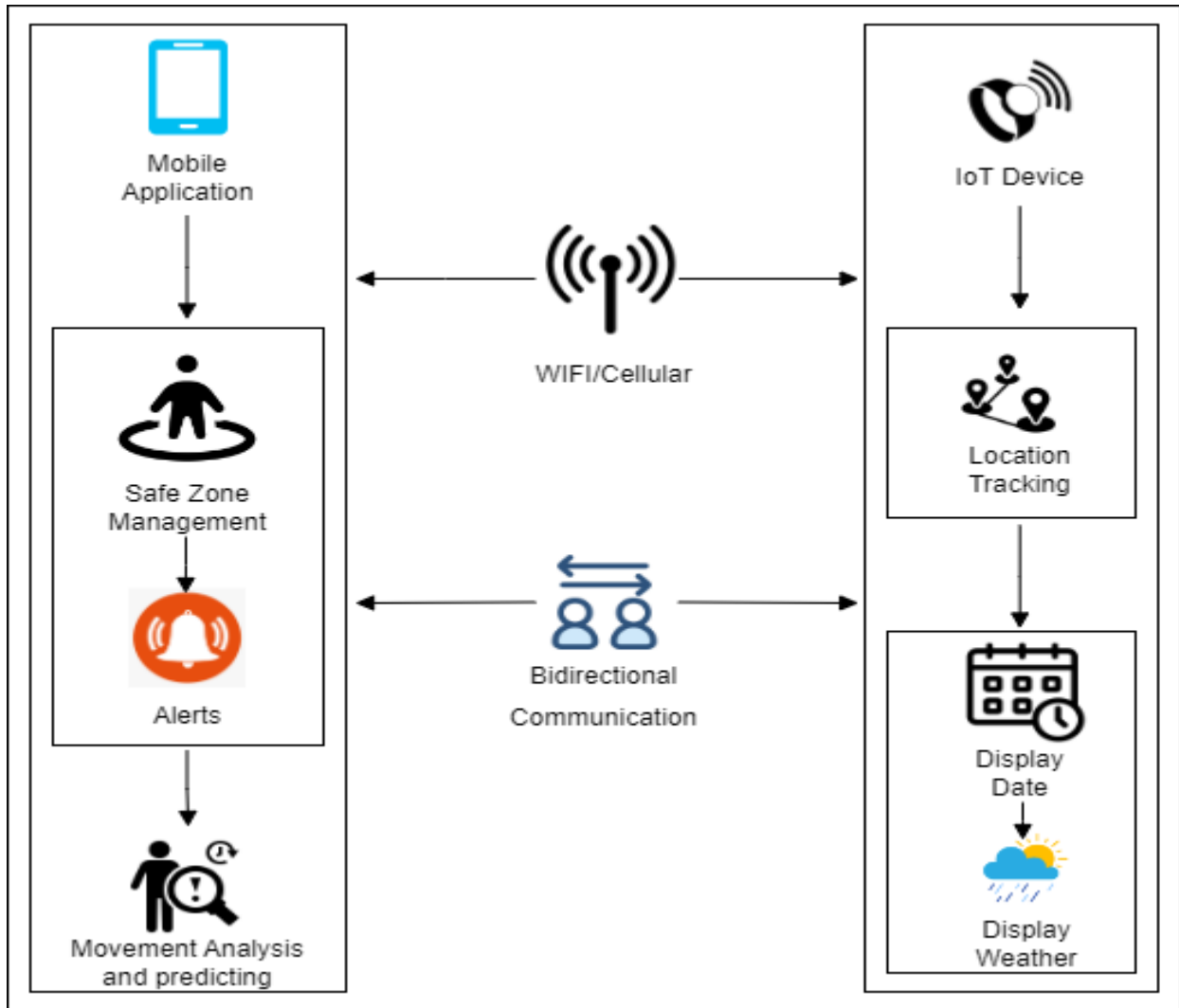


Figure 3. 1: Software Overview Diagram

### 3.2 The Flow of Project

#### 3.2.1 Requirement Gathering and Analysis

Gathering details and analyzing is the most important part of the initial period regarding this research study. By this phase, we can identify and organize all the requirements for the proposed device and system to be built. We must initiate this

step before starting the implementation to build a perfect solution. Below mentioned ways have been used for requirement gathering.

- Read research papers, articles, and journals about wandering.
- Identifying existing tools and devices.
- Conducting a survey to gather information.
- Have physical interviews with caregivers of some patients.

By studying research papers, we were able to identify and get exact ideas about the requirements. While reading research papers and articles, we were able to find out existing tools and devices and their current capabilities. This was helpful to identify the research gap. Data and information have been collected through a survey and interviews. The reason to do that in both ways is to get general people's perspectives and ideas, since our time was limited and physical interviews, were helpful to identify the requirements from the ground level.

### **3.2.2. Feasibility Study**

Schedule Feasibility:

- The proposed system with the device should be completed within the specified time. The Gantt chart shows the allocated time periods for each phase.

Technical Feasibility:

- To build the IoT device, team members need to have an understanding of the hardware and other physical components that are required. Then to build the mobile application, the team members of the research study should have knowledge of computer programming languages. New technologies and components need to be studied in order to build a perfect product.

Economic Feasibility:

- Since this research component included an IoT device, there are hardware and other physical components to be used. Under some cost constraints, all the members should use



their respective resources within the price range. A less expensive but more productive approach should be followed.

### **3.2.3. Implementation**

Producing the device and systematic functionalities should be done by focusing on already existing devices, tools, and systems. Some of the main complaints from users that are already existing devices are less accurate, expensive, and complex to use. So, by addressing those issues and adding new features, the IoT device should be built, and the system should be implemented.

### **3.2.4. Testing**

The product will be tested in a few phases. Alpha tests will be done at houses with a few chosen patients at a time. Then Beta tests will be done by connecting with consultants and clinics under their supervision. If there are any flaws or issues to be addressed in this phase, they will be acknowledged before releasing the product. (Important - These tasks will be done with the consent of the concerned parties.

## **3.3 Project Requirements**

### **3.3.1. Functional Requirements**

- Identify and monitor the patient's location constantly.
- Identify and establish correct safe zones upon the caregiver's input.
- Maintain historical records separately.
- Predict the patient's future movements.
- Display the current date, time and weather.
- Constantly monitor the patient's location.
- Maintain communication between the caregiver and the patient.

### **3.3.2. Non-functional Requirements**

- Accuracy – This is a key feature since one of the complaints from users is most of the existing applications are not accurate. It is important to show real-time data.
- Usability – System and operations need to be easily understandable by providing necessary instructions.
- Accessibility – Device and necessary instructions will be provided. The user only needs to have a smartphone.
- Reliability – Need to be reliable when displaying details such as date, time and weather.
- Well optimized – The device needs to be optimized well with the proposed system for the user to have a pleasant experience while using the mobile application.

### **3.3.3. User Requirements**

- Users should have a smartphone to use the mobile application.
- Users should have English knowledge to understand the instructions and given guidelines.
- Users must have some knowledge regarding mobile applications.

## **3.4 Commercialization**

To guarantee its efficacy and safety, the commercialization of a mobile app for dementia patients entails numerous regulatory considerations. Clinical trials and regulatory body permissions might be required for the app. Moreover, funding for the creation and promotion of the app could come from sponsorship from governmental organizations, academic institutions, or pharmaceutical firms. To expand the number of prospective users of the app and promote early diagnosis and treatment, it is also crucial to raise awareness of dementia among the public. Relationships with advocacy groups, professional associations, and healthcare organizations could assist spread information and connect with target audiences. Therefore, the development of a

mobile app for dementia patients necessitates a thorough strategy that takes into account legal, financial, and public health considerations.

## 4. BUDGET AND JUSTIFICATION

*Table 4. 1: Budget for the proposed system*

Item	Estimated Cost (LKR)
Device Creation	15,000
Hosting	10,000
App publishing cost on the Google Play store	5,000
Internet & Utility Costs	10,000
Total estimated cost	40,000

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## 5. APPENDICES

### 5.1 Gantt Chart

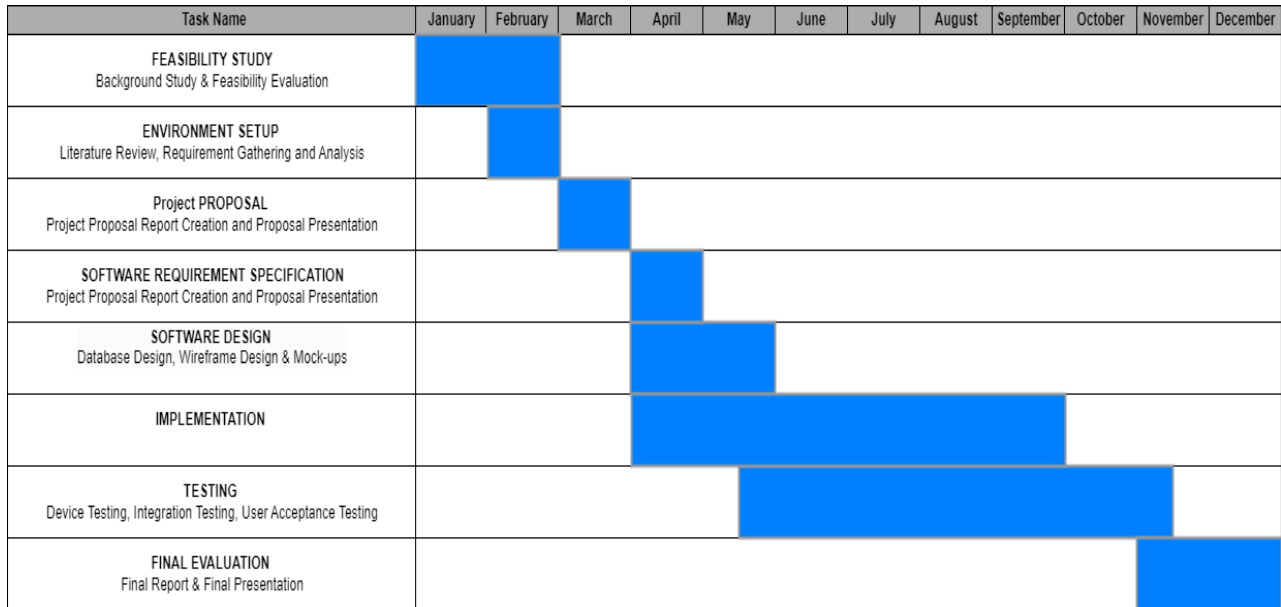


Figure 5. 1: Gantt chart

### 5.2 Work Breakdown Structure (WBS)

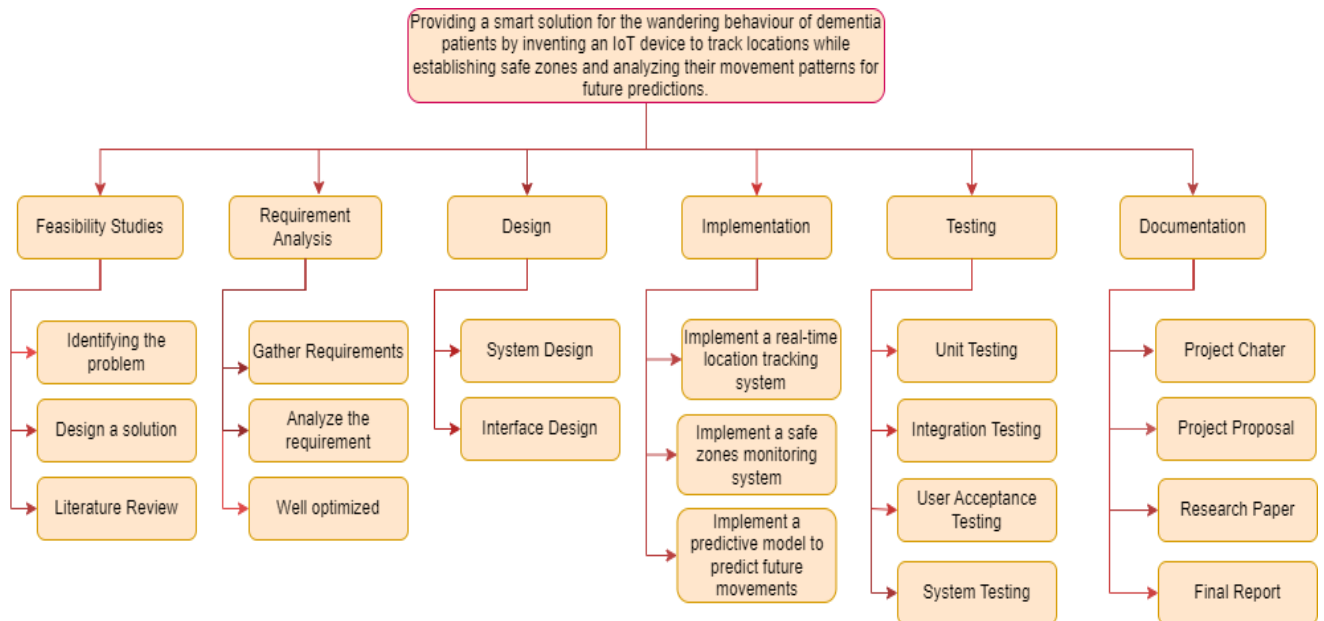


Figure 5. 2: Work Breakdown Structure (WBS)

### 5.3 Online Survey

## Survey conducted in order to get details on developing an IoT device for dementia patients.

Dear Respondent,

I'm a Final year student from the department of computer science and software engineering, faculty of computing , SLIIT

I'm researching about the wandering behaviour of dementia patients and its impact on caregivers lives in order to provide technical solutions to benefit both parties. This survey is conducted to gather some data required to proceed with the research.

 epunudantha777@gmail.com (not shared) [Switch accounts](#)



\*Required

Have you heard about Dementia ? \*

☐ Yes

☐ No

How much do you know about the disease ?

☐ I have never heard about it.



How much do you know about the disease ?

- ☐ I have never heard about it.
- ☐ I have only heard about it. Don't know much.
- ☐ I have some knowledge about the disease.
- ☐ I have studied/currently studying it.

Have you ever associated with a dementia patient ? \*

- ☐ Yes
- ☐ No

If the answer is "Yes", which age gap the patient belongs to ?

- ☐ Younger than 55
- ☐ 55 - 60
- ☐ 60 - 65
- ☐ 65 - 70
- ☐ 70 - 75
- ☐ Older than 75

As the caregiver, are you experiencing wandering as a habit of the diseased person ? \*

☐ Yes

☐ No

How often does the person wander ? \*

☐ Not at all

☐ Rarely

☐ Once a month

☐ Once a week

☐ Daily

☐ Multiple times a day

☐ Else

If the answer is "Else", please provide your answer ?

Your answer \_\_\_\_\_

Has the patient under your supervision experienced any fatal injuries / accidents ? \*

Has the patient under your supervision experienced any fatal injuries/ accidents because of wandering ? \*

☐ Yes

☐ No

If the answer is "Yes", please explain that experience.

Your answer

As the caregiver, you find it hard and stressful to keep up your focus with diseased person all the time ? \*

☐ Yes

☐ No

Out of the followings, what features do you think is most helpful in taking care of a dementia patient to ease our burden as the caregiver ? \*

☐ Track patient's location via mobile phone.

☐ Maintain constant communication with the patient while keep his or her independence.

Out of the followings, what features do you think is most helpful in taking care of a dementia patient to ease our burden as the caregiver ? \*

- ☐ Track patient's location via mobile phone.
- ☐ Maintain constant communication with the patient while keep his or her independence.
- ☐ Establish safe zones and and change them according to patients current whereabouts.
- ☐ Get alerts when person moves away from the defined border.
- ☐ Find and analyze the places where patients go frequently.
- ☐ Have no idea about this.

Have you ever seen any applications or tools with above mentioned features ? \*

- ☐ Yes
- ☐ No

What do you think about the accuracy of those existing applications and tools that have been build to aid the people with dementia ? \*

- ☐ Very much accurate
- ☐ Some what accurate

What do you think about the accuracy of those existing applications and tools that have been build to aid the people with dementia ? \*

- ☐ Very much accurate
- ☐ Some what accurate
- ☐ Neutral
- ☐ Not accurate at all
- ☐ Not sure/ Don't know/ Have not used any

What are the flaws you see on those applications/ tools ? \*

- ☐ Not user friendly for dementia patients
- ☐ Difficult to use
- ☐ Location tracking is not accurate/ Real-time location tracking is not available
- ☐ Alerting systems doesn't work properly
- ☐ Cannot see any flows
- ☐ Cannot/Hard give an opinion

**Thank you for participating in this survey and have a nice day !**

**Submit**

[Clear form](#)

## 5.4 Plagiarism Report

Assignment Inbox: RP-2023-Regular					
Assignment Title	Info	Dates		Similarity	Actions
Project Proposal Report	<a href="#">i</a>	Start	02-Mar-2023 6:22PM	7% <div><div></div></div>	<a href="#">Resubmit</a> <a href="#">View</a> <a href="#">Download</a>
		Due	30-Apr-2023 11:59PM		
		Post	10-Mar-2023 12:00AM		

Figure 5. 3: Plagiarism Report